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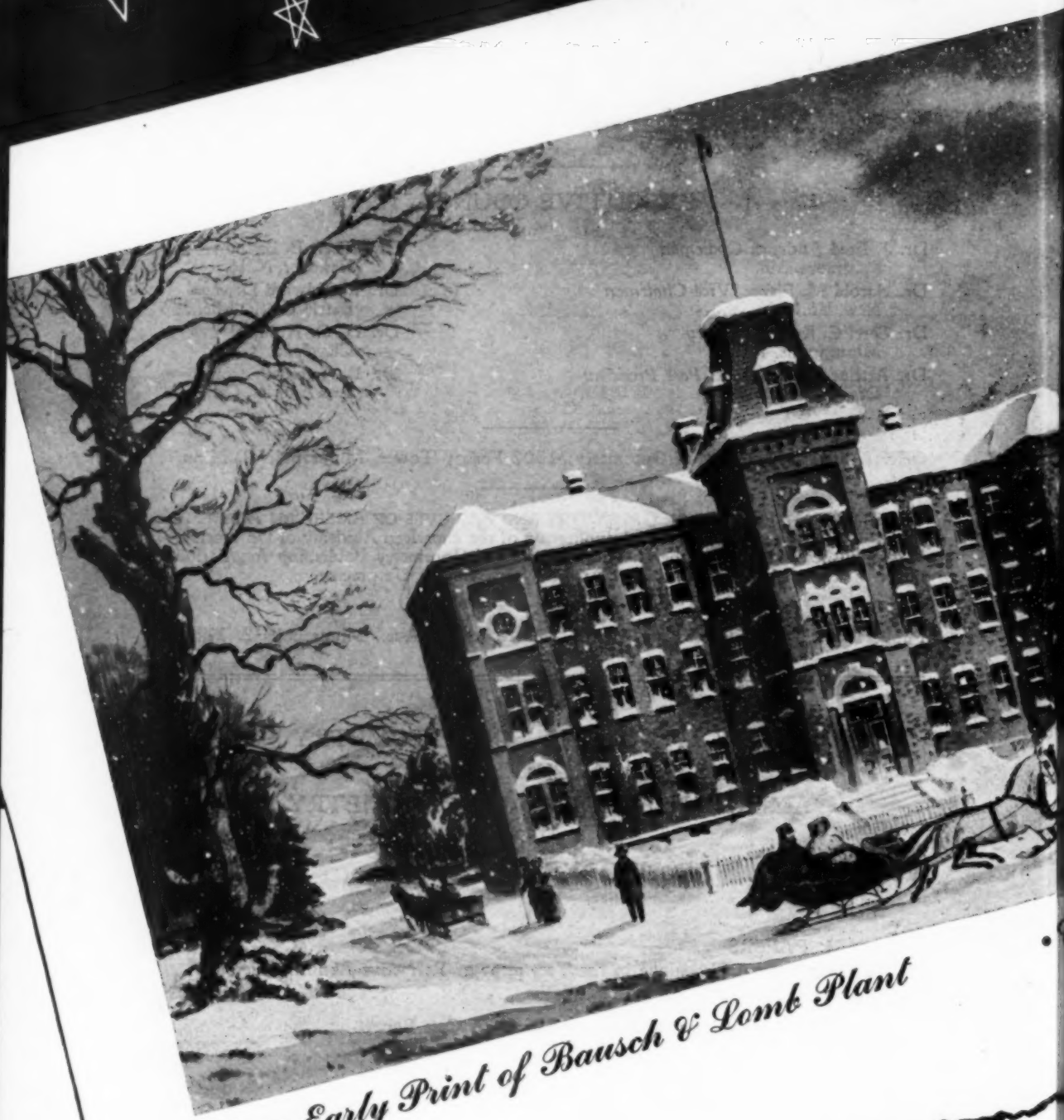

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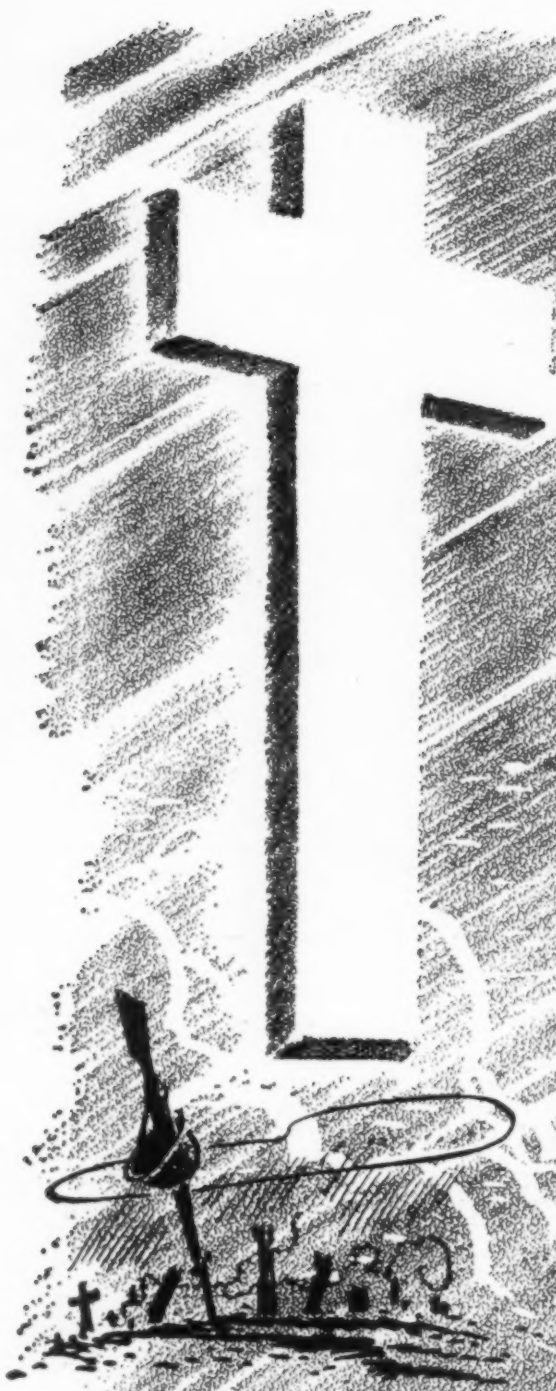

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Stilled is the shell and cannon roar,
As Armies of the World retreat
Unto Thy Spirit evermore.

Here on this Blessed Christmas Day,
When hearts and souls are shorn apart,
Show us Thy Holy, Righteous way,
Give us the blessings of Thy Heart.

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Pray that the world will soon disperse,
Those hearts grown old from enmity,
Give Peace, their lives to reimburse.

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A Star of Hope that did not wane—
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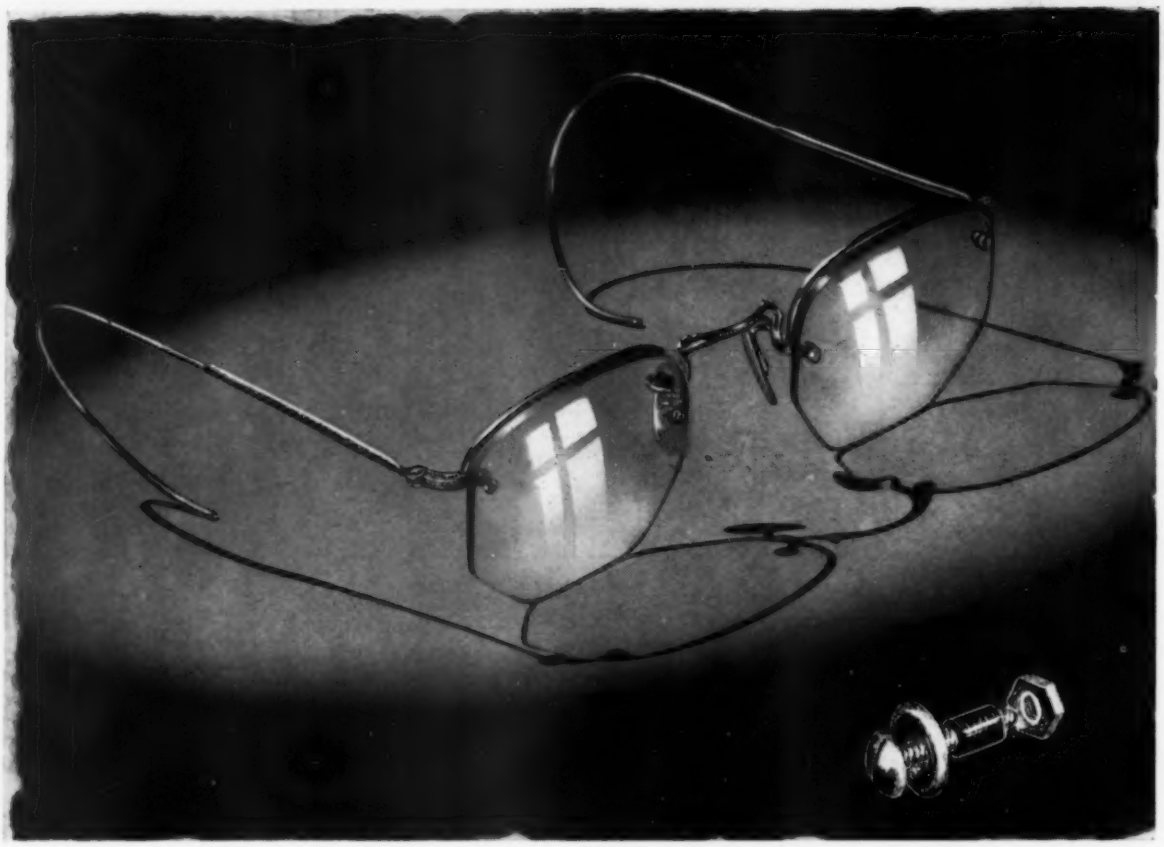

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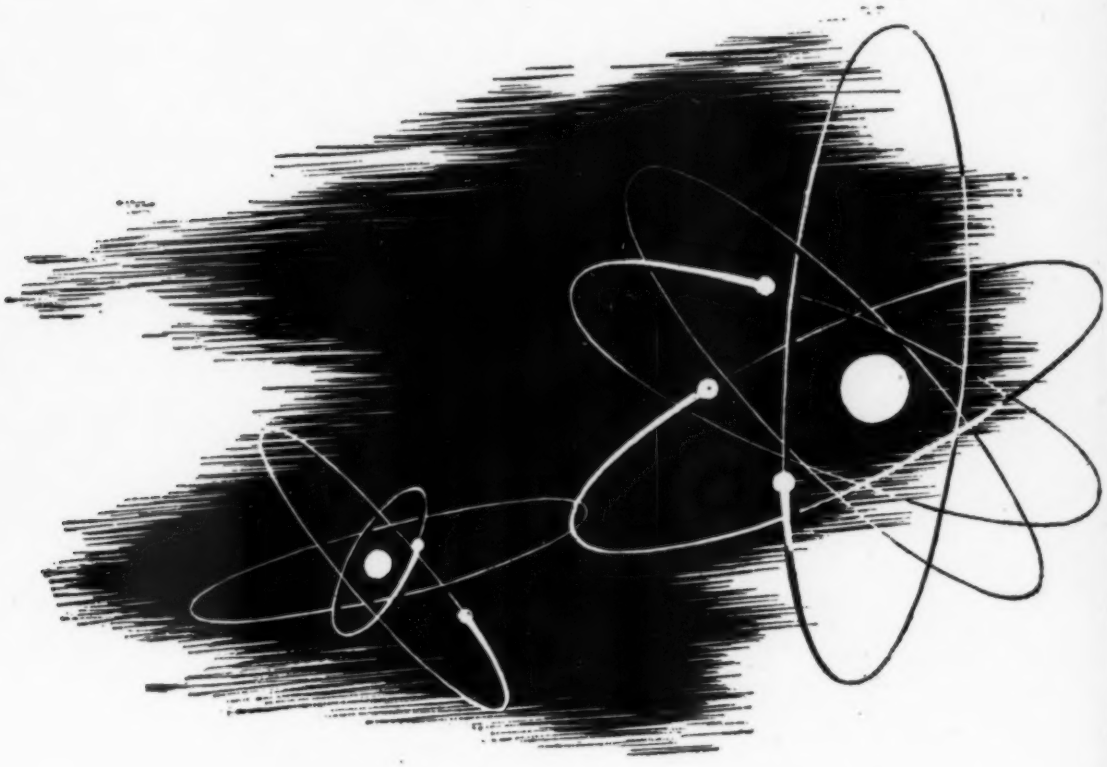

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Vol. 22 DECEMBER, 1945 No. 12

THE GRAF WISER TECHNIQUE IN THE TREATMENT OF REFRACTIVE ABNORMALITIES*

H. B. Marton, F. B. O. A., (Hons.)
Rusholme, Manchester, England.

At the present time considerable interest is being given to the work of Graf Wiser of Bad Eilsen.[1] The claims made by this distinguished oculist, and the ever expanding clientele which he enjoyed until his recent retirement have served to focus attention upon his methods of treatment which differ so markedly from conventionally accepted routine. The publication of the English version of his book "Prevention and Cure of Disease of the Eye" and Mr. W. B. Barker's review of it have placed before us fairly precise details of the methods used with the consequence that a number of refractionists have been disposed to experiment with them. The writer's acquaintance with the work of Graf Wiser goes back some years during which it has been his privilege to have had contact with about twenty patients who have been treated at Bad Eilsen. In every case the patient had considerable enthusiasm for the treatment given and all claimed to have received benefit from it. What was of particular interest to the optometrist was the peculiar corrections which had been fitted, for they were either convex lenses in the region of thirty-five dioptres or else ingenious combinations of high powered convex lenses and prisms. There was a marked absence of concave lenses and of astigmatic corrections. A perusal of the publications referred to above informs one that the Graf does not employ concave lenses even in myopia, and that he does not set great store on the use of cylindrical lenses in astigmatism, preferring to prescribe convex spheres in this condition also. Startling as are these claims they are supported by reasons and argument

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[1]Shortly after the original article was written, Graf Wiser passed away. At the start of World War II his clinic was being directed by his son-in-law.

which render them worthy of respect. If but one quarter of the teaching of Graf Wiser is ever proved to be correct it must of necessity completely revolutionize the prescription of lenses and the treatment of ametropia. Wiser has laid down quite definite rules for the treatment of faulty refraction, among which we find certain statements which declare that myopia is made worse by the wearing of concave lenses, that it can be cured by means of convex lenses, and that hypermetropia may become less if a suitable positive correction is worn during youth. Strabismus is considered to be due to strain upon the ciliary muscles. Again, it is dogmatically asserted that the influence of convex lenses increases and improves the circulation of the eye. This latter claim is most important for it postulates the therapeutic effect of the refractive correction which is the main, though not the sole, contention of the entire teaching.

Several cases have been treated by the present writer according to a modified Wiser technique and while no claim is made that their results are conclusive yet they have been sufficiently impressive to merit notice. It is proposed to discuss them in the following order :—myopia, astigmatism, strabismus, post-pathological conditions, and then to deal with the probable value of the treatment in so-called disease of the eye.

Myopia and its propensity to progress is a problem which if it could be solved would surely count as one of the major triumphs of applied science. The condition is usually considered to be that of an elongation of the globe, but some doubt may well be entertained as to whether all examples are of that nature. We know that but a slight reduction in the radius of curvature of the cornea can be responsible for the exhibition of an appreciable degree of myopia and such a small variation is well within the range of keratometric measurement. Again it is recognized that there is some association between excessive close work and the production of myopia in an eye with weakened tissues, and the consensus of opinion points to the act of convergence as being the mechanical factor in the elongation. Hence no one will doubt the value of base-in prisms in relieving such convergence. According to Graf Wiser the condition is caused by over-use of the ciliary muscles producing a true spasm of accommodation. He claims that the use of concave lenses establishes it and a morbid elongation of the globe results with a consequent defective nutrition of the ocular tissues. As a logical deduction from this he abolishes the use of concave lenses and substitutes convex and attends to the extra-ocular imbalance with prisms. With this in mind we may recall that some very successful treatment of ciliary spasm has been accomplished by refractionists who have employed base-in prisms to relax

convergence and then applied plus lenses to correct the hypermetropia which the dissociation of accommodation and convergence has revealed. If myopia has its origin in ciliary spasm then this form of treatment is entirely reasonable if it is instituted in its early stage, but it is difficult to see in what way convex lenses can influence a true axial error when once it has been formed, although one can appreciate that a spastic complication of such axial error could be removed by them.

The following is a case of myopia which is of particular interest in that it responded in part to a modified Wiser method. The patient was a female aged eighteen years, who had been fitted with a binocular correction of —5.50 sphere. Ophthalmoscopic inspection of the fundi revealed minute changes at the temporal side of each disc which in view of her age and their appearance suggested progressive myopia. The eyes were placed under the influence of atropine for one week and the refractive error proved to be the same as her correction indicated, the visual acuity for each eye being 6/6. In the subsequent treatment of this case practically every proposed method for the reduction of myopia was tried: these included the wearing of base-in prisms, sessions of "orthoptic" exercise designed to promote convergence relaxation, and the administration of a weak solution of atropine sulphate, hypertonic saline drops, adrenaline chloride, and the taking of calcium lactate orally. At a later stage she tried halibut liver oil because of the effect it had in another case of myopia which became less by half a dioptre. Even the methods described by the late W. H. Bates, M.D., in his book "The Cure of Imperfect Sight Without Glasses" were given a trial. The effect of all this treatment was entirely negative, the degree of myopia remaining the same as before.

It was decided to discourage the wearing of the concave correction, and reading exercises with a pair of plus 30.0 sph. were instituted. Each eye was occluded alternately to remove the complication of an induced muscular imbalance. At the end of six months the myopia was 3.50 dioptre and there it has remained. The patient states that at times her distance vision becomes reasonably clear for a few moments. The treatment is being continued.

Another case very similar to the above but with an initial myopia of 3.50 dioptres has responded to the extent of a reduction of one dioptre. The examination was conducted under atropine and the full correction supplied. Treatment was undertaken in a slightly different manner. Her uncorrected vision owing to a marked dilatation of the pupils was very poor. The Snellen test chart was set up at two metres and she could

read the 36 metre line. A pair of plus 0.50 spheres were placed before her eyes and produced a slight blur which presently cleared. At a later stage a further line became visible and this became blurred when weak plus spheres were applied, but became clear again. Finally she could see the twelve metre line with a binocular correction of plus 1.0 sphere. Exercise was then continued at six metres and the ultimate result was the ability to read 6/6 with a binocular correction of —2.50 sphere. No further relaxation has been brought about and this correction is worn with comfort.

It has been remarked that Graf Wiser prefers to treat astigmatic conditions with spherical lenses. This runs so much counter to the best teaching of our time whereby we are taught not despise even 0.12 dioptres of astigmatism that one is included to reject his statement as absurd. Yet to my certain knowledge the best refractionist whom it has been my lot to know was unable to tolerate the correction of his half dioptre of astigmatism and wore instead a pair of half dioptre spheres which completely freed him from his asthenopia.

Those of us who take it upon ourselves to treat conditions of strabismus frequently observe a change in the amount of corneal astigmatism as the treatment proceeds, while in certain non-strabismic conditions in which a temporary correction incorporating base-in prisms has to be worn it is not uncommon to find that small amounts of astigmatism become manifest which were not revealed before. Furthermore those who indulge in "orthoptic" treatment have a technique which they claim will render manifest astigmatism in those instances where the patient will not accept the full correction as shown by the keratometer. Certain tentative experiments have been made by the writer with a view to ascertaining the effect of an actual treatment of astigmatism as distinct from its optical compensation. The method has been to fit a near-point correction and permit it to be worn for some definite period. One case was as follows:—A man, aged 23 years. Corneal astigmatism of 0.50 dioptres axis vertical. Subjectively he took R. and L. +1.00 cyl. axis 90 degrees. A variable amount of esophoria was present for distance and near. The manifest amplitude of accommodation was 7.0 dioptres. Treatment lenses of +2.50 sphere were given for close work and were reported to be exceedingly comfortable. After one month the distance correction was R. and L. +0.75 sph. ⌒ +0.50 cyl. axis 90 degrees and the esophoric instability was not so marked. 3.0△ base-in was incorporated in the near-point correction. Two months later the distance correction became R. and L. + 1.50 sph. ⌒ + 0.25 cyl. axis 90 degrees, and the

extraocular imbalance was slightly exophoric. This correction has been worn for some time with comfort and is still in use.

On the other hand a very interesting case of astigmatism and vertical heterophoria was encountered. For years the patient accepted a low powered cylinder, but he had a corneal astigmatism of 2.0 dioptres. With the passage of time hyperphoria became manifest and with its correction his manifest astigmatism increased until at the present time he has 10△ of hyperphoria and 1.75 dioptres of astigmatism. From the behaviour of astigmatic eyes under the influence of plus spheres and base-in prisms it would appear that in certain instances this particular form of asphericity can be removed or lessened in amount, but in general there seems to be very little justification for such a procedure although some competent research may reveal something of value.

Most refractionists are interested in strabismus, paticularly in those examples of it that are amenable to refractive measures. Indeed it is only refractive strabismus which proves susceptible to non-surgical treatment, and because of this it is to be regretted that purely optical means of correction are not more widely used. The success of squint treatment is most marked in the young and we know that with such patients the proper exploitation of conventional refractive methods is most satisfactory. For older patients there is of course the adjunct which is provided by the technique associated with the school of Cantonnet. One cannot but help feeling that the value of this technique is somewhat seriously overrated and it is hardly likely to outlive its present vogue, but be this as it may optical methods have a certain value and it is perhaps not expecting too much to believe that in certain quarters such value will be appreciated. Several cases of strabismus have been treated along lines which are so closely paralled to the technique of Graf Wiser that no injustice will be done to the latter if they are quoted as illustrative of what a collateral adaptation of his methods can do. In the optical treatment of these conditions it is just as necessary to prepare the patient for it as it is when other methods are employed. Long ago it was laid down by such pioneers as Javal and Worth that the following steps were to be taken in the correction of squint:—

1. The restoration of simultaneous vision.
2. The production of fusion.
3. The establishment of stereoscopic perception.

Prior to the attempted restoration of simultaneous vision it is necessary to remove amblyopia and then to rid the patient of the propensity to neutralize the vision of the faulty eye when both are uncovered.

Occlusion of the sound eye is the most favoured treatment for functionally reduced vision, but to be effective it has to be prolonged and thorough. Normally such treatment is employed in conjunction with a tentative correction of the faulty eye. An attempt has been made to accelerate the process of recovery by fitting a special reading correction and having the patient use the eye in as direct and conscious a manner as possible, and when this has been done it is found that the subsequent neutralization does not prove difficult to remove. In actual practice the best objective result is found by means of keratometry and retinoscopy and then the hand types are presented to the patient when that plus sphere is found which it is necessary to add to enable him to read Jaeger No. 1 type. Such addition may well be in the region of 10.0 dioptres. As the vision improves the lens power is reduced until the small type can be read with the distance correction, which quite frequently requires revision owing to the action of the lens in uncovering latent error. Treatment at near must be continued until a satisfactory Snellen fraction is obtained for vision at six metres, and it is well to delay the uncovering of the sound eye for a little when this standard has been reached. When both eyes are left free, save for the refractive correction, the patient is encouraged to appreciate simultaneous vision and the same day that this uncovering takes place we endeavour to obtain fusion at near by means of plus lenses. Some little care is necessary for we may expect fairly rapid changes in the angle of strabismus, so that several sessions of testing may be necessary during that day and we must have the patient understand fully what we mean by fusion, or failing that maintain a close watch upon the behaviour of the visual axes. Under the influence of the test lenses the angle of deviation settles and the normal employment of fusion is brought about. It has long been known that a reading addition hastens the resolution of convergent strabismus but it does not appear to have been recognized that by careful testing it is possible to fit such additions that in a particular instance their common focus coincides with the far point of the static convergence. No great importance is given to the apparent inaccuracy of the visual axes passing through the lenses at a position other than their optical centres for the resultant base-out effect assists the act of fusion, but it does appear that slightly better results are obtained if an inward decentration is effected so that by incorporating base-in prisms we maintain the static convergence without an artificial compensation. This is a part that further exploration may clarify. The sole object of such lenses in whatever form they are given is to permit fusion and having done so their specific object is achieved.

The establishment of fusion in this fashion has much to commend it, for in the first place there is no call upon the ciliary muscles, and in the second the two foveae are placed in their functionally correct association without effort and therefore there is a definite incentive for them to act in concert. The enforced suppression of ciliary activity frequently causes accommodative relaxation with the result that any latency is revealed and the angle of deviation decreases in consequence.

One case was of particular interest in that it relaxed to the extent of 4.0 dioptres with the result that orthotropia was obtained with a full correction of the ametropia, other cases have been less spectacular yet have not failed to bear testimony to the value of the technique. As the relaxation of the convergence proceeds the power of the lenses is reduced until it becomes possible to have binocular vision at one-third of a metre with an addition of plus 3.0 spherical. We may then continue the treatment in one of several ways. The deviation can be corrected with base-out prisms which are decreased as the negative convergence becomes greater, or we may continue to work at the selected near-point and introduce base-in prism power into the correction. This appears to have excellent results, particularly if the increase of base-in prism power is continued until a total of 20△ is built up, for when this occurs the eyes are straight and it becomes possible to introduce a little base-in prism for distance. During this period or perhaps towards the end of it examination usually reveals the appearance of stereoscopic perception. The concluding correction is a full compensation of the refractive error usually combined with some degree of base-in prism. It will be apparent how closely this method follows that of Graf Wiser and it would seem that the final results are similar to his own.

The following cases of convergent squint have been treated in this fashion.

Miss C, aged 18 *years.* Left Convergent Strabismus of 20△ R. +0.50 sph. 6/6. L. +1.50 sph. 6/24.

Amblyopia treated with resultant visual acuity of 6/6. Fusion obtained at near with a binocular addition of plus 3.00 sph. This correction was fitted August 11th, 1938. Re-examined September 1938. R +2.00 sph. 6/6. L. + 2.25 sph. 6/6. Orthotropic.

Mr. D. E. aged 56 *years.* Visual acuity of each eye 6/36. Alternating Convergent Strabismus. An ophthalmologist of international repute described the condition as "hopeless." Under

treatment the visual acuity improved 6/18 and fushion was obtained at near with a total correction of R. and L. +11.25 sph. One month afterwards he had rudimentary stereoscopic perception. At the present time he wears R. and L. +9.00 sph. for distance and continues with the pair of +11.25 sph. for near. His visual acuity has remained at 6/18 but he has complete orthotropia and excellent stereoscopic vision. His previous correction was R. and L. +4.00 sph. It should be noted that the effect of the near point correction was shown within two months of treatment being commenced.

Sylvia B. aged 7 years. Right Convergent Strabismus. Wearing R. and L. +5.0 sph. prescribed by medical refractionist. Visual acuity R. 6/24. L 6/18. Fushion obtained with R. +8.0 sph. L. +7.00 sph.

Final correction

L. +5.50 sph. ⌒ +1.0 cyl. axis 30° 6/9.
R. +6.50 sph. ⌒ +1.0 cyl. axis 30° 6/9.
Orthotropic.

Divergent strabismus is treated with high powered base-in prisms which fully compensate for the deviation. Every effort must be made tc produce an equality of vision in the two eyes and the binocular apparatus must be encouraged to act normally while the prisms are in place, for it is only when the binocular partnership has become firmly established that we can hope to reduce the prism power. A typical case in given.

Miss A. aged 19 years. Left Divergent Strabismus.

R. —0.50 cpl. axis 90° 6/6.
L. —7.00 sph. ⌒ —1.75 cyl. axis 55° 6/18.

Fusion was obtained with 20△ base-in. This was worn for three months and then reduced to 15△. At further periods it was reduced to 8△ and then to 4△ until finally orthotropia was obtained for distance and near with the refractive correction alone. Visual acuity increased from 6/18 to 6/9. No reduction in the myopia could be obtained. In many conditions it would appear that a small degree of base-in prism should be incorporated with the ultimate correction.

It is not within the province of the optometrist to treat pathological conditions, but where the disease has run its course, or where competent authority has informed the patient that no further treatment

will be of service the refractionist may be called upon to help, and many of these sub-normal vision cases have received distinct benefit from the type of treatment here described.

Two cases of optic atrophy have been seen. One of these had been treated by Graf Wiser. In this instance one eye had lost light perception, while the other had exceedingly poor visual ability, yet with plus 35.0 spherical which had been fitted by the Graf fair sized print could be read.

The second case was encountered in the writer's own practice. The patient, a lady, had contracted some form of fever while living in the tropics twenty-five years ago. One eye had lost form vision and the other did not respond to conventional refractive treatment. Spectacles were made with a vulcanite disc for the useless eye and a plus 15.0 sphere for its fellow and with these she was able to read the print of her telephone directory.

An example of post irido-cyclitis responded in a very satisfactory manner. The condition had been active some twelve years previous to consultation and the patient had received conventional treatment at an eye hospital. Both pupils were reduced to a size slightly less than the smallest disc of the Haab Pupillometer. Direct ophthalmoscopy was not possible, but under the indirect method objects which were apparently situated in the vitreous could be seen. Field tests on perimeter and tangent screen were entirely unsatisfactory. Slit-lamp inspection of the anterior chambers proved that no pathological inclusions were present, but trans-scleral transillumination with the Wurdemann instrument revealed an uneven thinning of the iritic tissue.

Near point methods of testing resulted in:—

R. +25.0 sph. ⌒ 19△ Base-in.
L. +23.0 sph. ⌒ 16△ Base-in.

With this correction she was enabled to read small print with comfort and a marked but irregular dilatation of the pupils took place. The latter was apparent to her associates.

The dilatation permitted direct ophthalmoscopy to be performed and an extensive atrophy of the ocular tissues was revealed. Her vision is now 5/24.

A word may be said respecting the prescription of the prisms in this case. No particular rule was followed in their selection, but six distinct tests were made before the correction was made up. It must be appreciated that the entire case was treated experimentally.

One of the most commonly encountered conditions is that of cat-

aract, and it is somewhat surprising that it is so slightly esteemed by those whom we consider competent to deal with it. It is usually a sign of defective metabolism and it is recognized that such aberrant interchange need not of necessity be restricted to the area adjacent to the lens. The cataract associated with diabetes is a patent example of this, but even the ordinary senile type is not an uncomplicated phenomenon, and it follows that anyone who shows the earliest signs of such lenticular change should be the subject of a systematic examination by a physician. At the present time there are methods of prophylaxis which afford the uncomplicated condition a fair chance of escaping surgical attention, but it is well to realize that in the present state of our knowledge the condition cannot be cured, nor is it possible that a cure is likely unless at some time in the remote future biochemistry discovers a method of protein decoagulation which can be employed within living tissue. The greatest advance has been made in the methods of diagnosis and it is now possible to recognize the condition before opacification has been brought about and when this is done we may expect results from the now well-known sodium-calcium-iodide treatment. On the other hand the careful employment of this treatment will usually prevent further development even when opacity is found. Most refractionists have learned to appreciate the value of an accurate correction in this condition and it is true to say that attention to the ametropia will frequently provide the patient with a degree of useful vision for some considerable time.

In his treatment of cataract Graf Wiser lays especial stress upon the improvement of the ocular circulation, which is accomplished by the use of hot fomentations, and again and again he emphasises the value of convex lenses. From our own experience we can all agree that when a positive correction is worn the lens seems to take a longer time to develop opacities than where no correction is used, and it has been observed that an apparently rapid increase occurs with the wearing of minus lenses. If, with Graf Wiser, we believe that high powered plus improves the circulation of the globe then such is indicated in all cataract conditions. The exact selection of lenses in these cases is not a simple matter for one test alone or even one examination period is not sufficient to indicate the power or combination required. Examples have been found on more than one occasion where the results have varied as much as two dioptres. Whether one can attribute such to a latency of error it is difficult to say for it is exceedingly hard to conceive of a sclerosed lens being associated with such a condition. Not only so, but it has been found that much better results can be obtained at shorter distances than six metres and one

has had the experience of fitting a cataract case with lenses for two metres and then having prescribed them find the patient wearing them with comfort for visits to a cinema or a football match. The correction for close work has its own characteristics for it would appear necessary to fit a full correction for the point of regard and offset the divergence induced by means of base-in prisms.

For the purpose of this paper three cases of cataract have been selected from the records. One of which was treated at Bad Eilsen. The writer was consulted by this patient for a refractive correction. As a result of the examination the following was found:—

R. +1.25 sph. 6/6. L +1.25 sph. 6/6.

Early lens changes were present and when informed of this the lady elected to go to Germany to be treated. This she did and returned wearing:

R. +1.50 sph. L. +7.00 sph.

This correction proved difficult to wear but she persisted with it and ten months afterwards I examined her again and found:

R. +1.25 sph. 6/6. L. +2.00 sph. 6/6.

There was no perceptible change in the condition of the crystalline lenses. The Graf Wiser correction is still in use and the patient is kept under observation.

The second case was first seen about three years ago. The patient was a lady aged sixty years. Vision in each eye was reduced to 6/60 and she was waiting until she was fit for surgical attention. No satisfactory results were obtainable by conventional methods, so near-point tests were attempted and they gave:

R. +7.00 sph. ⌒ +1.00 cyl. axis 20°.
L.+8.25 sph. ⌒ +0.75 cyl. axis 140°.

22△ base-in were necessary to produce comfort with this correction. The patient was advised to bathe the eyes with a weak solution of sodium chloride (not "common salt"). At the present time she takes:

R. —2.00 sph. ⌒ —1.00 cyl. axis 110° V. A. 6/18.
L. —1.00 sph. ⌒ —0.75 cyl. axis 50° V. A. 6/18.

The third case was in some way similar to the first. The patient a man aged sixty-two years came for a presbyopic correction. Lens changes were found and he was advised to consult an ophthalmic surgeon. He consulted the surgeon of his choice and returned with a prescription of R. and L. +3.50 sph. The surgeon had informed him that the lens

opacities were of no moment, but if they became worse he could have surgical attention. He was something of an obtuse individual and wanted to know why something could not be done at an early stage and believed that spectacles might help. The writer consented to fit them if he would first have a general examination by his own medical practitioner. This he did and was found to have some heart trouble which later proved fatal to him. With a view to ridding him of a probable scource of toxins his dental surgeon removed four teeth.

Refractive tests resulted in:

R. +1.00 sph. ⌒ +0.75 cyl. axis 180° 6/9.
L. +1.50 sph. ⌒ +1.00 cyl. axis 180° 6/12.

On repeating the tests at two metres in we found that there was an increase of +1.00 sph. for the right eye and of +2.00 sph. for the left eye, and because of this the following were made up for constant wear:

R. +1.50 sph. ⌒ +0.75 cyl. axis 180°.
L. +3.00 sph. ⌒ +1.00 cyl. axis 180°.

For the first week of use they were almost unbearable owing to the blur produced, but afterwards he reported definite comfort. Six months afterwards he was re-examined and obtained a visual acuity of R. 6/9. L. 6/12 with this correction.

There was no sign of change in the lens opacities. After a further period of six months he obtained a visual acuity of 6/6 for the right eye, and in the case of the left eye a reduction of 0.25 dioptre in the sphere resulted in 6/6 also. The writer did not see this patient again for he went on a cruise to the West Indies and on returning home he succumbed to his heart trouble.

The above cases have been given as special instances where refractive treatment has appeared to have a good effect upon the cataractous condition.

Interesting as this ocular refractive treatment proves to be it is by no means a new treatment for in the past many have made claims for the therapeutic effect of lenses, and such claims have usually been so startling as to cause them to be dismissed as exaggerations. Towards the close of the last century the German ophthalmologist Schoen after years of study and patient research came to the conclusion that Glaucoma was due to over-exercise of accommodation and claimed that the prophylaxis of the condition by means of an accurate refractive correction was more to be desired than its relief by surgery.

About the same time there was the late Mr. George Edward Walker, F.R.C.S., of Liverpool. This ophthalmic surgeon was a man with an original mind as the curious may discover if they read his still extant "Essays in Ophthalmology." As early as 1879 he had made the claim that glaucoma was due to an excessive use of the ciliary muscles, and as he viewed the method of iridectomy with disfavour he designed an operative procedure of his own. In 1886 he exhibited certain cases before two meetings of the Ophthalmological Society in which he claimed that the wearing of refractive corrections had effectively influenced the condition. The claims and exhibits caused considerable discussion among the learned company present who did not appear to agree with hilm. Contemporary with these two was the eccentric individual Aristide Antoine Marie Fournet who treated glaucoma, cataract, progressive myopia, and other conditions with plus lenses, and who advocated and used high powered prisms in the treatment of strabismus. At this period it is perhaps impossible to assess his real worth, to some who knew him he appeared to be a charlatan, but others were willing to give him the adulation they esteemed his genius to merit. Today when we read over the few remains that he left or finger the modern sight-testing machines that he did so much to create we may perhaps have a kindly thought for him and the work he tried to do, and indeed, in which he often succeeded.

In concluding this paper the writer wishes to make it clear that he has no desire to assume an unqualified advocacy of the methods here described. They have been tried and the results are given above in so far as they have come within one's own experience. That they have a value is undoubted, but that such methods are final and conclusive no one will care to claim. The science of refraction has wide fields yet to be explored and if this paper has served to indicate a small corner of them it may not have altogether failed in its purpose.

DEFECTIVE COLOR VISION IN A FEMALE PATIENT* A CASE REPORT

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GENERAL HISTORY

Mrs. E. R. age 32. Patient requested an eye examination because her present glasses blur her vision and make her uncomfortable. She reported that at the age of 21 she had a paralytic stroke which affected her right eye, her speach and right arm. She spent several weeks in a hospital, but the cause of the stroke was never discovered. After three months all the symptoms suddenly disappeared "over-night", much to the amazement of her physician. Two years ago she accidentally fell and injured her head. Since then she has been subject to epileptic fits which were severe and frequent at first but lately have diminished in severity and frequency. She said that she can always tell a day in advance that she will have an epileptic fit because she developes a headache followed by a feeling of heaviness in the region of the head. The patient claims to save herself the embarrassment of having an epileptic fit in public by remaining indoors when she expects an attack.

OCULAR HISTORY

About seven months ago she decided to have her eyes examined, believing that glasses may relieve her from the occasional headaches. She was refracted and the following correction was given to her to be worn constantly: O. U. +1.50 D. spheres. She complains that her vision blurs with these glasses and that her right eye fills up frequently with tears. She was told by her doctor that eventually her eyes would adjust themselves to the glasses and the symptoms would disappear. After trying them for seven months she came to the conclusion that the glasses do not suit her eyes.

REFRACTION

Refraction of the eyes did not disclose unusual features. The ophthalmoscopic examination was negative. Her uncorrected vision was O. D. and O. S. 100%. Her accommodative ability was more than five diopters at the near point. Vision with the old correction was 80% in

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the right eye and 80% in the left. Vision with both eyes was 90%. Reduction of the plus to +.75 D. spheres increased her corrected vision to 100% and established a better accommodative-convergence relationship than with the correction that she had been wearing. She was advised to wear these glasses for close work only, for she presented a typical B2 type case.

COLOR VISION HISTORY

In the course of the examination the patient was tested for ability to discriminate colors and she immediately offered the information that we would find her to be color-blind. She was questioned for detailed history of her color vision and we found out that she is one of seven children—3 boys and 4 girls. Besides herself, her three brothers and two sisters have difficulty with colors and only one sister has normal color vision. She is positive that her father and mother are not color-blind for her father was employed by a railroad company and was required to pass a physical test each year. Her mother is a dressmaker and has excellent color vision.

The patient was asked, "When did you first become aware that you had difficulty with colors?" She replied that she became conscious of her defect at the age of 15 when she found herself in difficulty while attempting to match her cloths. She believes, however, that she must have had this defect when she was quite young, for she recalls being scolded by her mother for not bringing from the store properly matched spools of cotton, required by her mother in her occupation as a dressmaker. The mother, of course, did not suspect at that time that the patient had defective color vision.

"As a matter of fact," the patient said, "none of us children ever mentioned our lack of ability to see colors properly, and it was years later before the family discovered that my three brothers and my two sisters, besides myself, were color-blind."

COLOR VISION ANALYSIS

A. O. Co. Pseudo-isochromatic charts—Patient failed 39 out of 46 charts.

Ishihara Pseudo-isochromatic charts—Patient failed 29 out of 32 charts.
Dvorine Pseudo-isochromatic charts—Patient failed 23 out of 60 charts.
Her color discrimination was defective for the following color combinations: Red and green, red and brown, yellow and orange, yellow and green, blue and violet, brown and orange and green and brown.

Her color nomenclature was incorrect for the following colors:

Dark blue	Patient called purple.
Dark gray	Patient called green
Light brown	Patient called pink
Light orange	Patient called pink
Light violet	Patient called blue
Light gray	Patient called green
Holmgren Test	No confusion of colors.

SUMMARY

1. The case history of a female patient, age 32, has been presented, whose history disclosed that she suffered a paralytic stroke at the age of 21 and whose symptoms disappeared "over-night" after three months.

2. The patient had an accidental fall two years ago and following which she has been subject to epileptic fits which are now lessening in severity and in their frequency.

3. Routine examination disclosed that the patient has had difficulty with color discrimination since she was a child and that she has three brothers and two sisters with equally defective color vision. Both parents and one sister of the patient have normal color vision.

4. According to the Stilling and the Ishihara charts the patient is a red-green blind person.

5. The Dvorine Color Perception Testing Charts disclosed that the patient's color nomenclature is incorrect and that she has difficulty in discriminating the following color combinations: Red and green, red and brown, yellow and orange, yellow and green, blue and violet, brown and orange and green and brown.

6. The patient passed the Holmgren test without an error, which indicates the relative reliability of the test as a means of measuring color perception or color discrimination.

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LIGHTING AND SAFETY*

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The "Proposed American Recommended Practise for Compiling Industrial Accident Causes" (see Table I), lists nine causes, three of which are personal and six impersonal, or environmental. The National Safety Council assigns 70 per cent of all accidents to the one third of the causes listed as "personal" and only 30 percent to the two thirds of the causes that lie within the influence of the worker's environment. One of the six environmental causes, "improper illumination" (more inclusively, uncertain sight), is judged responsible for only four tenths of one per cent of industrial accidents. The insignificant percentage of accidents *attributed* to uncertain sight as influenced by lighting conditions is a measure of the educational job that faces lighting engineers in industry.

Light is not recognized as a major cause because it is the cause behind the cause. The truth of this statement is more readily recognized when the fundamental physiological function of the eyes is understood. The eyes are mechanisms for "survival." They are the major safety devices of the human animal. Their prime physiological function is to control the orientation and posturing of the body in its environment in such a way as to protect the body from hazards, or to gain benefits for the body, for example, in its search for food; that is, to ensure survival.

This is accomplished by a tie-in between the nerve networks of the eyes and the muscles so that reflex (automatic) actions may be initiated by the changing patterns of light in the eyes. This tie-in is exclusive in primitive forms of moving life so that their light-responsive organs initiate reflex actions of the muscular system only and do not convey images to a brain. In man this tie-in persists as an important mechanism for survival.

The ability of human beings to "see" is but one of the processes set into action by the eyes. Man is prone to recognize it as the only one, because it is the function that has enabled him to develop a civilization and to engage in cultural activities, but his individual safety and well-being remain closely dependent upon the light pattern that reaches his

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From National Safety Council Data
Table I. Accident Causes

	Relative Importance	Percentage	Accident Causes	Suggestions for Corrective Action
	1	30	Lack of knowledge or skill	Jop analysis Job training
The worker	2	20	Unsafe procedure Unsafe housekeeping Bodily defects	Formulation of safe procedure. Supervision discipline. Physical examinations
	3	19.1	Improper attitude	Supervision discipline. Personnel work to remove worry
	4	13.1	Agencies defective through use or design	Inspection. Proper maintenance
	5	9.5	Unsafe dress	Specify proper dress and equipment
The worker's environment	6	5.6	Improper guards	Inspection design with guards
	7	1.8	Unsafe housekeeping facilities	Supervision discipline. Job analysis; training
	8	0.5	Improper ventilation	Improve ventilation
	9	0.4	Improper illumination	Improve illumination

eyes from the entire field of view, rather than upon the stimulus received from the objects he can see clearly along his line of sight. If this light pattern, or a person's ability to react to it efficiently, is defective, that person is potentially unsafe, or accident-prone, in that environment.

Emphasis on the use of the eyes as visual organs only has led to the use of light in industry for seeing only, to the involuntary neglect of the need for physiologically safe-lighting conditions; and it is this same preoccupation with eyes as "seeing tools" that has delayed a full recognition of the major role that proper lighting can play in safeguarding all human activities.

Until the present time safety levels of lighting have been considered to be the least light necessary for seeing in the judgment of an observer who made a leisurely survey of a particular site. However, such a test does not take cognizance of the workman who trips over something. The foreman puts the accident down to a personal cause—carelessness—not realizing that, although there was enough light for the workman to have seen the bar if he had studied the floor, there was not sufficient light to attract his attention to the bar in time to prevent his stumbling over it at the normal speed at which the workman should and did move.

The old proverb, "Look before you leap," is sound advice, but it is no help in the dark, and a workman is always moving into physiological darkness when he moves from the relatively high level of brightness of

his work into a surrounding level to which his eyes are not adapted. It must be remembered that it takes 60 times longer to adapt eyes to a lower level of brightness than to a corresponding higher level.

There is not time in modern high-speed industry to make these downward adaptations; but, when they are not made, and an accident happens, the workman is charged with carelessness instead of the management's being charged with failure to make the proper environment adjustment to elementary physiological facts.

A great mass of reports dealing with "flying particles," "falling objects," "striking stationary objects," "falls," and "contact with moving machinery" has piled up and hidden the true cause of many accidents—uncertain sight.

Uncertain sight causes accidents:

1. When there is not sufficient light to reveal the hazard clearly.
2. When the level of illumination, although good for leisurely observation, is not enough to force the observer's attention to the hazard under normal conditions of speed and pre-occupation of the observer.
3. When the hazard is camouflaged by brightness, such as glare or by color which might give it the same brightness as the background and so conceal it, or by shadow which might hide the hazard.
4. When the eyes are defective. Defective eyes benefit from proper lighting, but the best light will not compensate for inherent eye defects. Such eyes should be corrected to normal.

What proof is there that accidents caused by improper lighting are a major group? First, there is the general proof of the paramount part played by sight as the major sense. Most authorities agree that more than 85 percent of our activities are controlled by sight and the remaining 15 per cent by the other four senses. Therefore, if accident causes were classified in relation to the senses involved, 85 per cent of accidents would be ascribed in whole or in part to uncertain sight.

A statistical study shows that 22 per cent of industrial accidents happen to the fingers. The implication is strong that, in the absence of sufficient illumination, many workers are forced to rely unduly on their sense of touch.

Accidents in homes are twice as great as accidents in industry, added to accidents in traffic, plus war casualties. Reason—homes are notoriously underlighted. Of the approximate 5,000,000 which occur in homes annually 21 per cent of these occur on the porch and outside steps—the two most poorly lighted locations throughout the major portion of each 24 hours most of the year. Another 12 percent occur in the halls, which

also usually are underlighted. The kitchen claims 18 per cent. This is often the best-lighted part of the home, but when the kind of operations that are performed in the kitchen are compared with their counterparts in industry it will be found that the kitchen is poorly lighted for the work done there. Average kitchen illumination is five foot-candles for work that industry lights to 20 foot-candles, and more recently to 50 foot-candles. In short, at least 50 per cent of home accidents occur in locations that lighting engineers know to be invariably underlighted.

The most striking proof lies in traffic-accident experience. For example, a traffic survey in Trenton, N. J., early in 1937 uncovered a relatively high percentage of night accidents, with a considerably higher incidence at 33 intersections. At these intersections night accidents were 59 per cent of the total, while in the city as a whole only 42 per cent of all accidents occurred at night. These intersections were then scientifically lighted. Injuries decreased 40 per cent and fatalities 50 per cent at night. The economic loss owing to the night-traffic accidents at the 33 locations before improvement was $89,900. After improvement the loss was $52,700. The improvement cost $3,292 per year, proving once again that it costs less to prevent accidents than to pay for them.

The relationship between light and accidents is clearly indicated in the traffic figures of the borough of Manhattan, New York. There were 118 daytime fatal crashes in 1941 and 151 fatal crashes at night, despite the smaller traffic load at night. In 1942 under dim-out conditions, although daytime fatal crashes dropped to 86 owing to fewer cars on the streets, fatal crashes at night jumped to 254.

During the dim-out period of the war, night-traffic accidents in six of the principal communities of Connecticut increased 56.7 per cent over the rate in the same communities when normal street lighting was used.

Detroit had 96 fatal night-time crashes on 100 miles of its streets selected for special study during the two years of 1935-36. Street lighting was scientifically improved on these streets in 1937. The total fatal crashes by night for the suceeding three years numbered 34. Examples of this kind can be cited indefinitely.

The objection has been raised that traffic-accident experience has no bearing on industrial-accident experience. The answer is that the eyes are obeying the same light stimulus, whether in night traffic, or in the factory, and are operating under the same physical and physiological laws. It is true that there are fewer complicating factors in analyzing traffic accidents so that the influence of lighting is more readily revealed.

However, the underlying biological facts leave no room for doubting the fact that faulty illumination is the crux of both the industrial- and traffic-safety problem.

Moreover, since the writer first published a tentative curve[1] relating the accident rate to the adaptation brightness of the field of view, a number of industrial cases has been recorded in the February 1944 *Illuminating Engineering*, which show specific reductions in accident rates in 14 industries as a result of the application of scientific lighting principles.

E. E. Dorting of the Board of Transportation of City of New York showed in the September 1943 *Illuminating Engineering* the results of five years' researches into the effect of lighting conditions on the accident rate on stairways and at transfer points (getting on and off cars, in New York subways). He found a drop of 59 per cent in stairway accidents and 52 per cent in transferpoint accidents as a result of suitably raising the illumination at these places. His results check the curve referred to, because his before- and after-brightnesses, applied to the curve, give accident-rate decreases similar to those found in practice.

As the rate of accidents caused by insufficient lighting depends upon the mean brightness of the field of view it can be affected by the reflection factors of the field of view. For instance, a black interior with 600 foot-candles of illumination would have the same light-accident rate (other things being equal), as a white interior with only eight foot-candles. The eye works with the light it receives, not with the light sent out by the lighting fixtures. This is the underlying reason for the increasing popularity of the scientific painting of machines and industrial interiors.

The lower the level of illumination the more important is this matter of lighter scientific finishes. If an illumination of 15 foot-candles were being used the portion of the accident rate dependent upon uncertain seeing would tend to be 150 per cent higher with 10 per cent reflection factor than with 20 per cent. That is, accidents caused by improper illumination would tend to be 10 per cent of all accidents with the higher reflection factor and 25 per cent with the lower, and so this matter of the proper application of paint and other surface finishes to the whole field of the view of the worker is highly important in accident control.

Another matter of great importance is the relation of design levels of illumination to actual in-service levels. Experience shows that in-service levels are more likely to run 40 per cent of the design levels rather than 70 or 80 per cent (figures customarily used by industry and lighting engineers in computing lighting levels).

The failure to look the facts in the face and realistically design

lighting installations has a bearing on the accident rate. Suppose an industrialist wants a safe installation and so sets the minimum field brightness at the required six foot-lamberts (for average industrial interiors); suppose also the average absorption of the field of view is the usual 80 per cent. If a 25-percent depreciation factor is optimistically assumed a design level of 40 foot-candles will be adopted. Experience will then show the brightness level to be three foot-lamberts instead of six and the accidents caused by improper illumination 50 per cent higher than they would have been if the six foot-lamberts actually had been realized. Such a mistake could have fatal results for one or more of the workmen and would be sure to cost the industrialist far more than he would save in the lower lighting cost.

Another point to watch in planning lighting for safety is to see that the work is at least as bright as the surround. If the general interior is brighter than the work, visibility goes down, and, if it is less than 40 per cent as bright as the work, visibility also goes down. It goes down faster for an overbright surround than for an underbright surround. Then, too, the light must be carefully controlled at the source to prevent the adverse conditions of too bright a surround (too much light sent to the surround), too dark a surround (not enough light sent to the surround) and interception.

In conclusion lighting for safety requires the abandonment of the archaic notion that lighting design consists simply of spotting outlets and putting some standard light source and accessory on them. There is no room for rules of thumb or salesmen's recipes when human life may depend upon the correct answer. Lighting for safety in industry, just as in traffic, requires engineering ability and engineering knowledge of a high order—in short, it needs the services of qualified illuminating engineers.

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REFERENCE

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ANNUAL REPORT OF ACADEMY SECRETARY

INTRODUCTION

We in the Academy are just concluding our 24th year of active participation, as an organization, in the affairs affecting optometric life. These 24 years have been both interesting and fruitful. They have seen refractive science make marked advances and they have covered a period of profound development in the mode of practice of optometrists. In these fields the Academy has played its part.

The year now coming to a close marks another milestone for both our profession and the Academy. It brought to an end a world-wide conflict which took many optometrists from their practices, and it served to

open the post-war era in which much attention will be given to all matters relating to health.

It was a year, too, in which the Academy made marked progress in its contributions to better visual care through

(1) The meetings of the Academy and its local chapters, wherein clinical and experimental research was seriously discussed.

(2) Academy grants of funds were made to assist specific research studies.

(3) Technical observations were published on matters relating to ocular science, and

(4) The Academy continued its leadership in the work of setting the tone of optometric practice.

ACADEMY MEMBERS IN MILITARY SERVICE

World War II has ended. It is fitting at this time that we in the Academy pause to record and to honor those of our Fellows who have served as members of the armed forces. Those optometrists and scientists who through their loyalties and desire to serve, have left their practices and laboratories to devote those energies and skills and life itself if needed, in the Allied cause.

Twenty Fellows of the American Academy of Optometry were in military service. Many are still in uniform.[1] As far as is now known, all have survived although several have had rather difficult experiences.

We are thankful that these men came through their war time trials—we are grateful to them for the contribution they made to national defense, and we welcome them back to civil life.

To preserve for all time the specific parts carried in the military forces by these members, the writer presents the following brief summary of those war time activities as is now known:

Dr. Mathew Alpern, 105 Conger Avenue, Akron, Ohio. T/5, United States Army. Entered service October 21, 1942. Present status, active duty. Serving in the American theatre of war. Duties, Optometrist, Medical Department, Hospital Center, Camp Carson, Colorado.

Dr. Theodore Henry Feinman, 1019 Kennedy Avenue, Duquesne, Pennsylvania. Lieutenant, United States Naval Reserve. Entered service, September 10, 1942. Persent status, active duty. Served in the European and Mediterranean theatres of war,

[1]As written on November 1, 1945

first as officer in charge of an amphibious vessel and later as a hospital specialist.

Dr. Harold M. Fisher, 7 Park Avenue, New York, New York. Captain, United States Army. Entered service February 24, 1943. Placed on inactive status January 12, 1945. Served in the American theatre of war. Duties, Personnel testing officer. (Stereoscope)

Dr. John H. Gregory, 133 East Main Street, Benton Harbor, Michigan. Captain, United States Civilian Air Corps. Entered service February 20, 1943. Placed on inactive status, January 17, 1945. Served in the American theatre of war. Duties, administrative.

Dr. John Jacob Hausman, 756 South Wilton Place, Los Angeles, California. Ensign, United States Naval Reserve. Entered service October 15, 1943. Present status, active duty. Served in the American and Southwest Pacific theatres of war with Fleet Hospital 108 at Guadalcanal and Noumea, New Caledonia, in charge of Mobile Optical Unit No. 2.

Dr. Henry A. Imus, Dartmouth Eye Institute, Hanover, New Hampshire. Lieutenant, United States Naval Reserve. Entered service September 25, 1944. Present status, active duty. Serving in the American theatre of war. Duties, research in ophthalmology.

Dr. Mervyn H. Kauhl, 210 Schofield Building, Cleveland, Ohio. 1st Lieutenant, United States Army. Entered service August 11, 1943. Present status, active duty. Serving in the American theatre of war. Duties, Medical Administrative Corps activities at Regional Hospital, Fort Knox, Kentucky.

Dr. Ralph Kullander, 1004 Equitable Building, Des Moines, Iowa. Captain, United States Air Corps. Entered service, October 1, 1942. Present status, active duty. Serving in the Burma, China and India theatre of war as a pilot.

Dr. Ralph M. Marshall, 241 San Anselmo Avenue, San Bruno, California. Lieutenant (j. g.), United States Naval Reserve. Entered service July 28, 1942. Present status, active duty. Serving in the American theatre of war. Duties, optometric refractionist.

Dr. Marshall A. Marvelli, 2651 Montclare Avenue, Chicago, Illinois. Ensign, United States Naval Reserve. Entered service,

January 31, 1942. Present status, active duty. Serving in the American theatre of war. Duties, optometric refractionist.

Dr. Harold W. Oyster, Peoples Bank Building, Marietta, Ohio. Lieutenant, (j. g.) United States Naval Reserve. Entered service April 1, 1944. Present status, active duty. Serving in the Pacific theatre of war. Duties, communications officer.

Dr. Earl H. Ridgeway, 140 West State Street, Trenton, New Jersey. Seaman First Class, United States Coast Guard Reserve. Entered service December 18, 1943. Present status, inactive duty. Served in the American theatre of war. Duties, served on part-time basis as temporary reserve with Flotilla No. 13 in various capacities of coast defense on anti-submarine off-shore patrol, life boat station, communications, etc. Now on unassigned list for emergency work only.

Dr. Eugene W. Strawn, 425 South Beaver Avenue, Freeport, Illinois. Major, United States Army. Entered service September 7, 1941. Present status, active duty. Serving in the American theatre of war. Duties, Chief, Mobilization and Reports Branch of the Military Training Division, Office of the Chief of Transportation, Pentagon Building, Washington, District of Columbia.

Dr. H. Douglas Tansley, 1045 Wolseley Avenue, Winnipeg, Manitoba, Canada. Sergeant, Royal Canadian Army Medical Corps. Entered service October 19, 1942. Present status, active duty. Serving in the Canadian Home War Establishment. Duties, optometric refractionist.

Dr. Ernest C. Wille, Jr., 10110 South Winston Avenue, Chicago, Illinois. 1st Lieutenant, United States Army. Entered service, January 14, 1943. Present status, active duty. Serving in the American theatre of war. Duties, Ambulance Platoon Leader, 78th Division. Personnel Officer, 114th General Hospital. Optometrist for six weeks while in pool awaiting assignment. Commanding Officer, Hospital Company, Station Hospital, Fort Baker, California. Commanding Officer, Detachment of Patients. Medical Administrative Corps.

In addition, the following members have also served in the armed forces. The exact military status of these men is now not known.

Dr. R. F. Coops

Dr. W. Edward Dewey

Dr. Charles E. Jaeckle
Dr. J. J. Sampson
Dr. George Winston

We in the Academy honor these men for their service to country and the Allied cause. By this service they have contributed to victory and at this time we of the Academy pay tribute to these loyal optometrists and fellow members.

LOCAL CHAPTERS

The start of 1945 found the Academy functioning with four active local chapters. These were the Cuyahoga Chapter, the Michigan Chapter, the New York Chapter, and the Southern California Chapter. Each of these Academy affiliates was doing and has continued to do, a good job.

During 1945 five new local chapters were organized and received charters from the Academy. These chapters were the Indiana Chapter, the Iowa Chapter, the Maryland Chapter, the New Jersey Chapter and the Vermont Chapter. In addition, the Minnesota Chapter was reorganized under new leadership and is again functioning.

These new chapters bring the total of Academy locals to ten—each functioning actively in its respective sphere. These chapters exert powerful local influence upon all optometrists and bring close to home the professional ideals which constitute an important portion of the general program of the Academy.

Plans are now under way to establish additional local chapters during 1946. The Academy will continue its program of refunding to each active local chapter $2.00 for each practicing optometrist member of the local who is also a Fellow of the Academy. The funds so refunded to be used for extension purposes of the local chapter.

MEMBERSHIP

Upon appropriate action, 75 optometrists, scientists and educators have been awarded Fellowship in the Academy by the Executive Council during 1945. These men were brought into the Academy upon the recommendation of members and also through the joint action of some of our local chapters who have proven themselves invaluable in screening applicants and assisting the officers of the Academy in this work. We welcome these new members, and feel sure their associations in this society will prove both stimulating and mutually helpful.

ACADEMY LOSSES BY DEATH

I regret to announce that during the year we lost three members

of the Academy by death. These men had been active in the Academy and each had made his marked contribution to the well-being of his profession. At this time the Academy pays tribute to Dr. Harry Getrosh of Lorain, Ohio, Dr. John W. Morey of Ridgewood, New Jersey and Dr. B. S. Palmer of Boston, Massachusetts.

PROGRAM AND PAPERS COMMITTEE

At the 1944 annual meeting of the Academy the Program and Papers Committee was made a standing committee of the Academy. The wisdom of this action becomes apparent in reviewing the outstanding program arranged for the 1945 annual meeting. Dr. D. G. Hummel and Dr. H. W. Hofstetter have supervised these activities and to them and their associates is due the credit for the excellent program presented at this meeting.

RESEARCH PROJECTS COMMITTEE

The Research Projects Committee under the Chairmanship of Dr. Robert E. Bannon has reviewed and screened several special visual studies which seemed worthy of Academy aid. During June of this year a grant of $500.00 was made for visual research to the University of California, School of Optometry, for work to be done by Dr. Meredith W. Morgan. During the late fall a $1,000.00 grant was especially set aside to assist in a special visual study in which the value of cycloplegics may be a part. Additional funds for use as Academy grants will be available during 1946 and those wishing to apply should send an outline of their proposed research study to the office of the Academy, where it will be given consideration by the committee.

SPEAKERS BUREAU

During the year an Academy speakers bureau was formed under Dr. Richard Feinberg, who serves as Chairman of our Speakers Bureau Committee. The purpose of this newly created group is to supply speakers to our local Academy sessions for their periodic meetings as well as to supply speakers for general gatherings of optometrists.

During this year several of our members who volunteered to speak have been called and others will no doubt be placed on programs during 1946 as this Academy service becomes more widely known. The Speakers Bureau Committee would appreciate additional listings of Fellows who are qualified to address optometric meetings on any of the many special topics in our field.

ROSTER

During 1945 an Academy roster was published. This booklet of 40 pages contained both an alphabetical as well as a geographical roster of Academy Fellows. In addition, the Academy Constitution and by-laws were presented.

Additions and changes in membership during 1945 now make this roster obsolete, and a new 1946 edition will be published and mailed to the members shortly after the first of the year.

EXAMINING BOARD

During 1945 the Academy examining board has made arrangements to conduct certain Academy entrance examinations with the assistance of local Academy chapter examining committees, who will serve under the supervision of the Academy examining board. The Southern California Chapter at Los Angeles has already appointed an examining committee and both the Indiana and Minnesota chapters will do likewise in the near future.

Similar examining committees will be organized in other local chapters. This work is being carried forward by Dr. Richard M. Hall, Chairman of the Examining Board.

SPATIAL SENSE AND MOVEMENTS OF THE EYE

The English translation of Edward Hering's "Spatial Sense and Movements of the Eye" by our Fellow member, Dr. Carl A. Radde, published by the Academy, continues to sell. It is true that the volume of sales is not large—but it is steady and the small remaining stock of books will be sold in time at $5.00 each. Both Dr. Radde and the Academy should take great pleasure in this special venture. The translation was well done and this English version of this outstanding text meets with universal approval.

THE FINANCIAL POSITION OF THE ACADEMY

On January 1, 1945 the Academy had cash on hand in the amount of $3,168.07. This total including $2,869.69 on deposit in the Academy account in the Northwestern National Bank of Minneapolis and $298.38 in the Academy account in the Bay Street Branch of the Bank of Montreal at Toronto. These latter funds were frozen in Canada. In addition, it had accounts receivable in the form of 1945 dues from its members of approximately $3,150.00.

Against these reserves were $565.65 of unpaid 1944 Academy bills, these being in great part the result of our December 1944 annual meeting, and an anticipated 1945 annual budget, which under a vigorous

Academy program as approved by the Executive Council amounted to a total of $5,015.00 for the 12 calendar months of 1945. This annual budget included the anticipated costs of running the Academy during 1945, the costs of the 1945 annual meeting and also included a $1,500.00 annual appropriation by the Academy for visual research work.

It was obvious, therefore, that to properly maintain the Academy's fiscal position that two courses of action had to be simultaneously followed by the officers of the Academy. These were

(1) Close adherence to anticipated and estimated costs as approved in the 1945 annual budget, and

(2) To take such proper steps so as to somewhat increase the total income of the Academy during 1945.

This latter step could only be accomplished by inviting a small select group of qualified optometrists into Fellowship in the Academy during 1945.

Both plans were followed, and on December 1, 1945 the fiscal position of the Academy was as follows:

Cash on hand in the amount of $4,834.41. This total includes $4,456.55 on deposit in the Academy account in the Northwestern National Bank of Minneapolis and $377.86 in the Academy account in the Bay Street Branch of the Bank of Montreal, at Toronto. In addition the Academy had accounts receivable of $285.00.

Against these current reserves were the remaining unexpended appropriations as set up in the 1945 annual budget in the amount of $3,437.00 As the majority of these annual Academy operating costs fall due in December, these funds will be in great part expended during this month in accordance with prior approved budget plannings. Following the payments of these Academy accounts it is now anticipated that the Academy will have an unencumbered balance on hand as of December 31, 1945 of $1,702.41. It should also be borne in mind that with our present membership we will start the year 1946 with a dues account receivable of approximately $4,600.00.

THE EXECUTIVE COUNCIL

As Secretary I wish to express my sincere thanks to each member of the Executive council for their splendid assistance to the Academy office which extended throughout the year.

Academy business is largely transacted by the Executive Council, and these members, being in practice in various parts of the country,

are called upon to act on behalf of the Academy largely by mail. This requires a painstaking attention to detail and a day-to-day "follow-through" in the many matters presented to the Council for their attention. In this our present council, in full, has carried its responsibilities well, never shirking or delaying its individual action. The Academy is in debt to these fine men for their untiring efforts.

PRESIDENT, DR. J. FRED ANDREAE

On behalf of the Academy's secretarial office, I would like to express our appreciation for the understanding and cooperation we have received throughout the year from our President, Dr. J. Fred Andreae of Baltimore, Maryland. Dr. Andreae, through his many fine years of active association with the Academy has an outstanding insight into Academy problems and with his wide acquaintance in optometric circles has a splendid background for solving these problems. As our Chief Executive, Dr. Andreae has contributed very much indeed to the success of this year's activities in the Academy.

CONCLUSION

As the annual sessions of the Academy open in Columbus, American aims and ideals have triumphed in the most severe test this country has ever faced. From the shadow of near defeat which swept across this shocked land on that bleak December Sunday in 1941, we have emerged four years later with great victories to add to the proud book of American History. In all this, optometrists have played a part. Some have carried arms. Others have practiced the refracting arts in the armed services, while others still have labored to conserve vision on the home front for the war tasks which were so pressing.

We in the Academy well remember December 7, 1941. The Academy was in session at the Morrison Hotel at Chicago. Early in the afternoon Dr. A. P. Wheelock, our President, was called from the room. He shortly returned with the stunning news of Pearl Harbor. Following a brief recess the Academy carried through its three-day program, and before adjourning pledged its wholehearted support in the conduct of our war effort. These pledges have been kept.

We now face the post war era with confidence. Optometry has a big part to play in restoring our economy to a peacetime normal and optometry will rise to the occasion. Here, too, the Academy has its part to play. It is the writer's privilege to report that this professional society is now equipped to do its job in the reconstruction period ahead.

CAREL C. KOCH

SPECIAL REPORT

A PHYSICIST'S SUMMARY OF ATOMIC ENERGY*

The basic ideas of the atomic bomb and the utilization of atomic energy are found in the physics of several decades ago. In 1912 Rutherford, known best for his work in radioactivity, wrote in a text, "the continuous emission of energy from the active bodies is derived from the internal energy inherent in the atom itself, and does not on any way contradict the law of the conservation of energy. At the same time, however, it indicates that an enormous store of latent energy is resident in the atoms themselves. This store of energy had not been observed previously, on account of the impossibility of breaking up into simpler forms the atoms of the elements by the action of the chemical or physical forces at our command." In another book written in 1941 by Pollard and Davidson, we find, "if someone could succeed in isolating a few pounds of U^{236} and the whole were to be submerged in water, very interesting developments would almost certainly follow. The separation of the uranium isotopes in quantity lots is now being attempted in several places. If the reader wakes some morning to read in his newspaper that half of the United States was blown into the sea overnight he can rest assured that someone, somewhere, succeeded." During the period from the early years of the twentieth century to 1940, scientists in the physics laboratories set the stage for August 6, when the first atomic bomb was dropped from an airplane. In the earlier phases of the work, in fact until 1940, it was not realized that a bomb could result from the researches that had been carried out. The research work was done to learn more of the world around us. In so doing, many useful discoveries were made. In the series of discoveries that led to the atomic bomb, radioactivity plays a central role.

ATOMIC STRUCTURE

To understand the atomic bomb we must have some idea of the structure of the atom. Although the physicist has never seen an individual atom, he can tell you much of its structure and be fairly certain he is correct. At least, prediction of results in terms of the present theory of

*An abridgment of the material presented by Dr. J. W. Buchta, Chairman of the Physics Department, University of Minnesota, in an article, "Atomic Energy" which appeared in Minnesota Technolog, Vol. 26., No. 1., October, 1945.

the atom found to be valid and, therefore, the physicist has some confidence in his theories.

The atom is electrically neutral; that is, it contains as much positive as negative electricity. The atoms are extremely small and there are many of them. Their size and number may be partially realized when we say that if we were to count at the rate of one million per second the number inhaled with each breath, it would require about 500 million years. Each atom has a central core or nucleus which contains practically the entire mass of the atom but which is very small compared to the space occupied by each atom. This space is a little difficult to define. The tiny central nucleus is charged electrically positive. About it in orbits (not too sharply defined) are negatively charged electrons. If the atom were enlarged until these electronic orbits were a yard in diameter, the nucleus would be about $\frac{1}{1000}$ inch in diameter. It is this nucleus that concerns us in atomic energy. The space between the nucleus and electrons is empty.

FUNDAMENTAL BUILDING BLOCKS

The nucleus of each atom differs from one kind of atom to the next in that is contains different numbers of the fundamental units called protons and neutrons. The proton is a positively charged body—the size of the charge being the same as that of an electron but opposite in sign. The weight of a proton is about 2000 times that of an electron. The neutron is a body having the same weight (very nearly) as the proton, but it has no charge. These particles are so fundamental that we cannot describe them in terms of other more elementary bodies or particles. However, for some purposes we may consider the neutron as the combination of an electron (negative) and a proton (positive), and for other purposes we may consider the proton as the combination of a neutron and a *positive* electron.

The hydrogen atom is the lightest and simplest of all. Its nucleus is a single proton, and about this nucleus revolves one electron. The helium nucleus contains two protons and two neutrons. Its charge is, therefore, twice that of a proton and its weight four times that of the hydrogen atom (very nearly). The next element, lithium, has protons in its nucleus and four neutrons. Its charge is, therefore, three times that of the proton—we call this its atomic number—and its weight seven times that of the proton — we call this its atomic weight. The most

complex atom known several years ago had 92 protons and 146 neutrons in its nucleus. Its atomic number than is 92 and its atomic weight is 238. It is called uranium.

The weights have been given in whole numbers. Actually they are not exactly multiples of the weight of one proton. Sometimes the weight (mass) is slightly more, sometimes less than an integral mutiple of the proton (or neutron). Thus the combination of a number of protons and neutrons may result in an actual gain or loss of mass. *Mass is not conserved*

ISOTOPES

In addition to finding a hydrogen atom, with one proton as a nucleus, we also find a hydrogen atoms with one proton and one neutron. This "heavy" hydrogen has the same charge (atomic number) as the ordinary hydrogen but has a larger atomic weight. It is called an isotope of hydrogen. Isotopes, atoms of equal atomic charge but different atomic weight, are found in nature for practically every element. There is a lithium atom with three protons and three neutrons, and a uranium atom with 92 protons and 143 neutrons. Its weight is, therefore, 92 + 143 = 235. We often write $_3Li^6$ or $_3Li^7$ to represent the lithium isotopes—all of charge 3, but one with mass 6 and the other mass 7 (nearly). The uranium isotopes would be indicated by $_{92}U^{235}$ and $_{92}U^{238}$. The U^{235} we see in the newspapers refers to the isotopes $_{92}U^{235}$.

The charge on the nucleus (atomic number) determines the number of electrons that surround the nucleus, which, in turn, fix the chemical properties of an atom. Thus $_3Li^6$ and $_3Li^7$ have the same chemical properties and are both called "lithium" by the chemist. The chemical properties of $_{92}U^{235}$ and $_{92}U^{238}$ are the same. Combinations of atoms such as H_2O, H_2SO_4, etc., involve adjustments in the arrangements of the electrons but do not involve any changes in the nucleus. The nuclei of the hydrogen (H) atoms and of the oxygen (O) atoms in these molecules are identical.

RADIOACTIVITY

There is a process, however, in which the nuclei of atoms are changed. That is radioactivity. In radioactivity the *nuclei* of atoms undergo changes. For example, the nucleus of uranium may break up and eject a helium nucleus (called then an alpha particle). This process may be represented by

$$_9U^{238} \rightarrow {}_2He^4 + {}_{90}UX_1^{234}$$

Then a new element uranium X_1 is formed. Some radioactive elements

eject an electron (beta particle) instead of ejecting a helium nucleus (alpha particle). An example is the nucleus ${}_{90}UX_1^{234}$. That process may be written ${}_{90}UX^{234} \rightarrow {}_{91}UX_2^{234} + {}_{-1}e^{0}$ in which ${}_{91}UX_2^{234}$ represent a new element of atomic number 91 and atomic weight of 234, and ${}_{-1}e^{0}$ represents an electron of O (nearly) mass and charge —1. Notice these equations balance with respect to charge and mass on the two sides: $92 = 2 + 90$, $238 = 4 + 234$, $90 = 91 - 1$, $234 = 234 + 0$. The process of forming new elements is often called transmutation. We can now observe in the laboratory a process long sought unsuccessfully by the alchemist.

The ejection of the electron *from the nucleus* when it contained only protons and neutrons may be puzzling. Here is an instance in which we may consider the neutron to be made up of a proton and an electron. We may say that in the process of disintegration the nucleus "manufacturers" an electron, ejects it, and the net result is the disappearance of a neutron and the appearance of a proton. The atomic weight does not change, but the atomic number is increased by one unit. A number of the heavier atoms are found to be naturally radioactive. The rate at which the disintegration goes on varies greatly and is measured by determining the "half life" of an element. For example, if we should start with a million radium atoms, we would find one half had disintegrated in 1600 years, if we start with a million UX_1, atoms, one half would change in 24 days. These times are called the half-life periods.

CONSERVATION OF MASS AND ENERGY

In the disintegration process, some energy is released. The Curies found that their samples of radium would remain warmer than the surrounding objects for an indefinite period. The radioactive process supplied energy which appeared as heat. Here was the first evidence of available energy from the atom—atomic energy. On the theoretical side, Einstein showed that the source of this energy was the actual mass of the reacting atoms. Mass disappeared and in its place energy was created. No longer can we say matter cannot be destroyed or that energy can neither be created or destroyed. Rather we say that energy and mass taken together are conserved. If one disappears, the other appears in its place. The relation between them is

$$\text{Energy} = \text{Mass} \times (\text{Velocity of light})^2$$

Since the velocity of light is great, the energy created when mass disappears is large. The conversion of one gram of water (or any material) into energy would yield enough heat to raise the temperature of two hundred thousand tons of water from freezing to boiling. Theory indi-

cates, and we feel certain it is correct, that it is the conversion of mass (matter) to energy that supplies the sun and stars with their radiant energy.

NUCLEAR CHEMISTRY

An ordinary chemical reaction, such as the burning of coal (carbon) may be represented by

$$C + O_2 = CO_2$$

The equation "balances." The atoms of carbon (C) and oxygen (O) are accounted for on both sides of equation. But today we have a new chemistry, nuclear chemistry. An illustration is:

$$_2He^4 + {}_7N^{14} = {}_8O^{17} + {}_1H^1$$

Helium nuclei may join a nitrogen nucleus and form oxygen and hydrogen. The equation balances as to charge, $2+7 = 8+1$, and mass, $4 + 14 = 17 + 1$, at least as far as rough values of the mass are concerned. A more complete equation would be

$$Energy_1 + {}_2He^{4.0388} + N^{14.00750} = {}_8O^{17.00450} + {}_1H^{1.00812} + Energy^2$$

in which the masses are given more accurately and it is recognized that it is mass + energy that is conserved and not each alone. In this case the masses on the left hand side are less than those on the right. Hence, the $Energy_1$, must be greater than $Energy_2$. Energy must be added to carry on the reaction.

Another example of nuclear chemistry is:

$$_4Be^9 + {}_1H^2 \rightarrow {}_5B^{10} + {}_0N^1$$

If beryllium is bombarded with "heavy" hydrogen nuclei ($_1H^2$) (deuterons), the result is boron and neutrons. This reaction serves as a source of neutrons. It is reactions such as these that are produced in the "atom smasher." To produce the reactions with $_2He^4$ or $_1H^1$ or $_1H^2$ these positively charged particles must be given high velocities in order that they may enter against the repelling force of the positively charged nuclei of other atoms. The energy that much be given to them is sometimes measured in electron volts, or million electron volts (M^{ev}). One M^{ev} is the is the energy acquired by an electron in passing freely between two conductors whose potential difference is one million volts.

Since neutrons have no charge, it is easier for them to enter and unite with positively charged nuclei. Examples of this reaction are:

$$_{35}Br^{79} + {}_0n^1 = {}_{35}Br^{80} \qquad {}_{11}Na^{23} + {}_0n^1 = {}_{11}Na^{24}$$

The bombardment of bromine and sodium nuclei with neutrons pro-

duces nuclei with the same atomic charge (atomic number) but increased atomic weights. These nuclei are unstable and are radioactive. The radioactivity is said to be "induced" in contrast to the "natural" radioactivity of some elements. For example, the nucleus of the sodium of atomic weight 24 in time ejects an electron and becomes magnesium.

$$_{11}Na^{24} \rightarrow {}_{12}Mg^{24} + {}_{-1}e^{0}$$

This sodium has a half life of 15 hours.

AVAILABILITY OF ATOMIC ENERGY

We are now prepared to discuss the possibilities of obtaining atomic energy on a large and practical scale. Theory has indicated the equivalence of mass and energy. Laboratory experience had shown that theory was correct, but no practical means of obtaining atomic energy had been indicated before 1940.

As early as 1934 Fermi and his colleagues in Italy obtained some puzzling and interesting results when uranium was bombarbed with neutrons. Because of the lack of repulsive forces due to electrical charge, the neutron can more easily enter atomic nuclei of large atomic number (large charge), such as that of gold and other elements near the end of the periodic table of the chemist, than can charge particles such as protons. The usual result is a nucleus one unit heavier but with the same atomic number, hence the same chemical properties. However, on the bombardment of uranium with neutrons, Fermi obtained atoms with different chemical properties. It remained for several German physicists to interpret correctly the results of Fermi. They advanced the hypothesis that the uranium atom was not disintegrating in the usual manner of radioactive substances but that it was breaking up into two or more parts of about equal mass. Physicists at once recognized what such a process portended. The "packing" of protons and neutrons in the nuclei of elements of atomic weights about half that of uranium is large; hence, if uranium breaks up into these elements, mass is converted into energy, and relatively large amounts of energy were predicted.

It was also recognized that neutrons may be given off in the process, now called fission, and thus if the process were once started it might maintain itself; in fact, it might become a chain reaction which would release energy at enormous rates. But if such were the situation, why did not such processes take place in nature and thus cause all of the uranium now on the earth to disintegrate? Some natural phenomena, such as cosmic rays or lightning, might yield the initial neutrons.

The answer to this question was given through work done by Dr.

A. O. C. Nier, in the Department of Physics at the University of Minnesota.

We have stated earlier than uranium is found to have two isotopes, U^{235} and U^{238}. Nier by use of his mass spectrograph, a device which uses electric and magnetic fields to separate isotopes, was the first to separate sufficient U^{235} from U^{238} to show that it was the isotope U^{238} which experienced fission when bombarded by *slow* neutrons. The isotope U^{238} did not divide when neutrons were added to it. Nier and physicists at Columbia University co-operated in this work. The Columbia physicists had a cyclotron and related apparatus available for making the complete test. Since natural uranium contains only one atom of U^{235} to 140 of U^{238}, it was now realized why the cumulative chain reaction did not take place in nature. The concentration of U^{235} was not sufficiently high. Theoretical work based on the absorption of neutrons by uranium indicated that if U^{235} was obtained relatively pure and in a sufficiently large piece, then the fission process once started would proceed with explosive violence and release energy at rates never previously imagined. When, in 1940, the possibility of such a chain reaction was suspected although not yet proven experimentally, the studies of the process of fission, work on the separation of U^{235} from U^{238}, and related studies were all placed under strict governmental control. There was a blackout on any news of such work.

The amount of material separated by Nier was measured in micrograms, millionths of a gram.

Pounds of it would probably be required for a bomb. Scientists were at once given the task of devising ways of separating the isotopes of uranium. It must be remembered that the isotopes cannot be separated by ordinary chemical means. Chemically, they are identical. Methods must be used which depend on the differences in masses of the atoms U^{235} and U^{238}—and to add to the difficulty, the desired U^{235} is only $\frac{1}{140}$ as abundant as U^{238}.

PREPARATION OF MATERIAL FOR A BOMB

The principal methods actually used for separation of U^{235} and U^{238} were based on diffusion, and the deflection of charged atoms in electric and magnetic fields. Because U^{235} is slightly less massive than U^{238}, the average speed of the U^{235} atoms in a gaseous state is larger. By allowing a uranium compound in the vapor state to pass through "diffusion" barriers (which we cannot now describe in more detail), the

more rapidly moving U^{235} atoms were obtained in relatively larger numbers. By setting up many stages in enormous plants, a sufficient enrichment was eventually obtained.

The arrangement of electric and magnetic fields in the mass spectrograph had been demonstrated by Nier as one method of separating the isotopes, but at first it was not thought possible to collect enough U^{235} by such devices. Nier once estimated that by operating his machine 70,000 years a practical amount of U^{235} might be obtained.

However, the technical difficulties of both methods, the diffusion and electromagnetic, were solved, largely because cost and use of manpower were secondary matters. Each of these methods required vacuum conditions and known purities of the gases involved. In detecting leaks in the gigantic vacuum system and in the analysis of the vapors, the mass spectrograph as developed by Nier "deserves special mention." "Acres of barriers and thousands of pumps" were required and the maintenance of these was a technical problem of an order of magnitude never previously attempted.

THE NEW ELEMENTS, NEPTUNIUM AND PLUTONIUM

Laboratory work shows that two other elements, thorium and protoactinium, undergo fission when bombarded by *fast* neutrons. Protoactinium is very scarce and at present thorium, requiring *fast* neutrons for fission, has no advantages over uranium.

In producing fission in U^{235}, the neutrons, whatever their source, must be slowed down to low velocities — at least low in comparison to that at which they are usually produced. In studying the possibilities of a chain reaction in U^{235}, it was exposed in its usual combination with U^{238} to neutrons slowed down by bombardment with other nonabsorbing atomic nuclei. A suitable material for "moderation" of the initial neutron speeds is carbon—graphite. In the use of large "piles" of uranium and graphite, it became evident that a new element might become available as a source of atomic energy. It was realized that the nonfission capture of neutrons would probably yield a new radioactive nucleus. Theory predicted and experiment verified the following processes:

$$_{92}U^{238} + {}_{0}n^{1} \rightarrow {}_{92}U^{239} \rightarrow {}_{93}Np^{239} + {}_{-1}e^{0}$$

$$_{93}Np^{239} \rightarrow {}_{94}Pu^{239} + {}_{-1}e^{0}$$

The capture of a neutron by the nucleus $_{92}U^{238}$ leads to $_{92}U^{239}$. This nucleus is radioactive with a short half life, and like radioactive sodium $_{11}Na^{24}$, emits an electron and becomes a nucleus with an increased charge, in fact, a new element, called neptunium ($_{93}Np^{239}$). Neptunium is also

radioactive (half life also short) and on the emission of another electron from its nucleus becomes plutonium ($_{94}Pu^{239}$). The theory of fission predicted that this nucleus would behave like U^{235} with respect to fission, and experiment verified the result.

Here, then, was an element which would serve as well as U^{235} and since its differed in atomic number, it had different chemical properties and could be separated *chemically* from uranium. If it could be produced in sufficient quantities, it could be used as well as U^{235}.

The problem of producing it and separating it was solved. Great piles of graphite were built up with blocks of uranium inserted in them. The fission of U^{235} was started by neutron sources but controlled by the concentration of the uranium and by the insertion of shields (e.g. cadmium) which were very good absorbers of slow neutrons. The controlled fission of the U^{235} produced a number of neutrons, more than one per nuclear fission. These entered the U^{238} and the reactions described above were initiated. When a certain amount of the new element Pu was formed, the uranium was removed from the graphite pile and the associated Pu separated chemically. Thus a second material for atomic bombs was available, and two new elements were added to the list of elements.

ATOMIC BOMB

Parallel with the work on the separation of U^{235} and the production of plutonium, experiments were carried on to determine the possibility of using these elements in a bomb. The nuclei of Pu^{239} and U^{235} broke into parts on the addition of a neutron somewhat as a drop of water may be broken if it is made too large by the addition of water. But the analogy, although good for some purposes, does not indicate the kinetic energy given to the parts. For our purposes, we may imagine powerful springs compressed between the two halves of the nucleus and a trigger mechanism actuated by the neutron such that the springs could be released and impart high velocities in opposite directions to the fragments of the nucleus. The velocities of the fission fragments greatly exceed those of equal mass in any explosion of TNT or other "chemical" or "molecular explosion." Comparisons of the energy in an atomic bomb with tons of TNT are usually meaningless to us. Not many of us know of the destruction produced by even a few pounds of TNT. We may, however, have seen the results of a local tornado. Its path of destruction may be a fraction of mile wide and several long. Its action may take place over a number of minutes. The bomb finally devised, produced even more complete destruction over a larger area, and its action is com-

pleted within a second or two. It is terrible. Nothing approaching it in power has previously been under control of man.

The details of the actual construction of the bomb are not available for publication. One can say that the bomb must contain a certain minimum of the active elements and that arrangements must be made to expose suddenly the fission elements to a source of neutrons. The very rapid disintegration is required to produce the intense destructive pressure wave.

The entire project, leading up to the final bomb, required team work on the part of hundreds of scientists and technical men to an extent never before attained or attempted. Men were called from universities and industry. Each group was given its own task, often without knowing just how it would fit into the whole pattern. Our own University at the beginning of the project loaned the services of Dr. Nier. Later Dr. John H. Williams and a group of graduate students joined the group at Los Alamos near Santa Fe, New Mexico, after some preliminary work had been done by them in our own laboratories. Equipment from our atom smasher was transferred to another site; in fact, the atom smasher must remain idle until the equipment is returned or replaced. Other universities, including Chicago, Harvard, Wisconsin, California, Princeton, and Illinois, also released equipment which was essential to their own researches. In addition to the co-operation of various universities, the U. S. government contributed most freely when it became evident that the possibility of success existed. We should stress here the word "possibility" as success was not assured from the beginning. Vast sums were spent and large plants built on trust in the scientist's calculations and without the usual trial pilot plant. Those who held the purse strings had faith in the scientist and were willing to accept his prediction—at least, they were willing to do so in times of stress!

PEACETIME USES OF ATOMIC ENERGY

There was a time when the scientists could, and many did, hope that some principle would emerge which would prove an atomic bomb inherently impossible. But that hope faded. The project group has continually kept before it the possible peacetime uses although the war emergency did not permit active work on such phases.

Now that peace is here, the major attention will be on practical peacetime uses of atomic power. Already the use of graphite to slow down neutrons has yielded a major tool for the biological sciences. Some neutrons are absorbed by the carbon nuclei and produce a radioactive

form of carbon of long life. Carbon is the most important element in living matter. The radioactive form may be used as a tracer element in many biological processes. It also affords a tool to the organic chemist who can now trace carbon atoms by the radiations emitted.

Other elements may also be made radioactive by similar methods.

The press has carried many stories of the applications of atomic energy. Our new cars may carry a capsule which would furnish energy for the life of the car. A new house may have its heating plant built in and need no fuel for the first twenty years. An airplane may fly around the world without stopping. Rockets may be sent to the moon. The use of coal and oil may be outmoded. Even our waterpower plants may be less convenient because of their size than an atomic energy plant. A scientist cannot say these are impossible—but neither can he now say they are to be a part of our immediate future. The span between the present status of atomic power may be as great as that between the discovery of fire and the invention of the steam engine. But with the present pace of technical developments the span can hardly be that great.

Atomic energy may be opening a new era as profound as the discovery of America. Posterity may look upon this present period as we look upon days when sailing vessels were kept within sight of land. It is as impossible for us to predict accurately the future as it was for Columbus to describe the America of today.

At present it is possible to utilize only a few elements for sources of atomic energy. But the day may come when other elements may be used or the conversion of mass to energy to be done more completely. At present only about 1-10 of 1% of the mass of uranium is converted to energy.

The geographical frontiers may vanish but science has unending frontiers before it.

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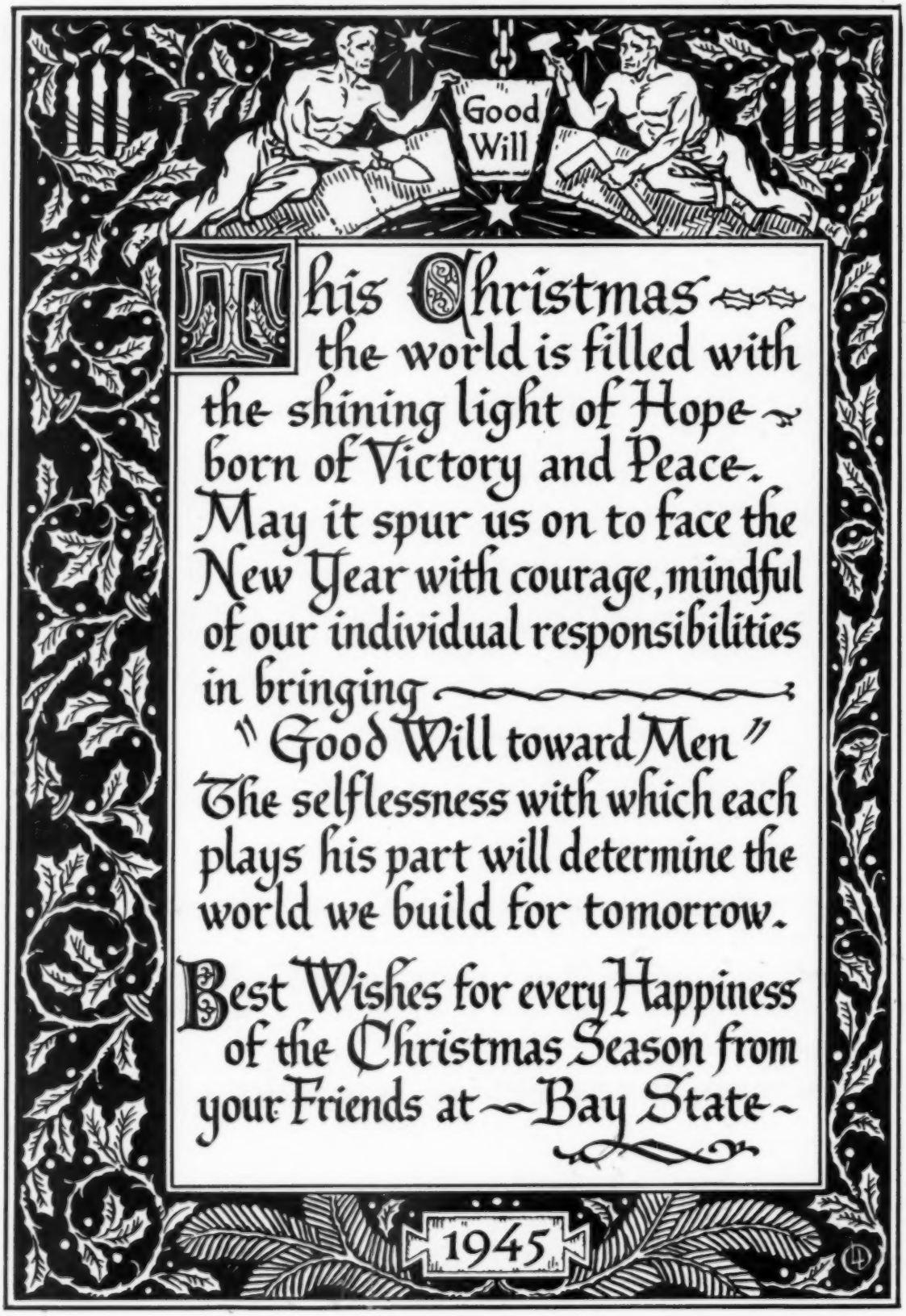
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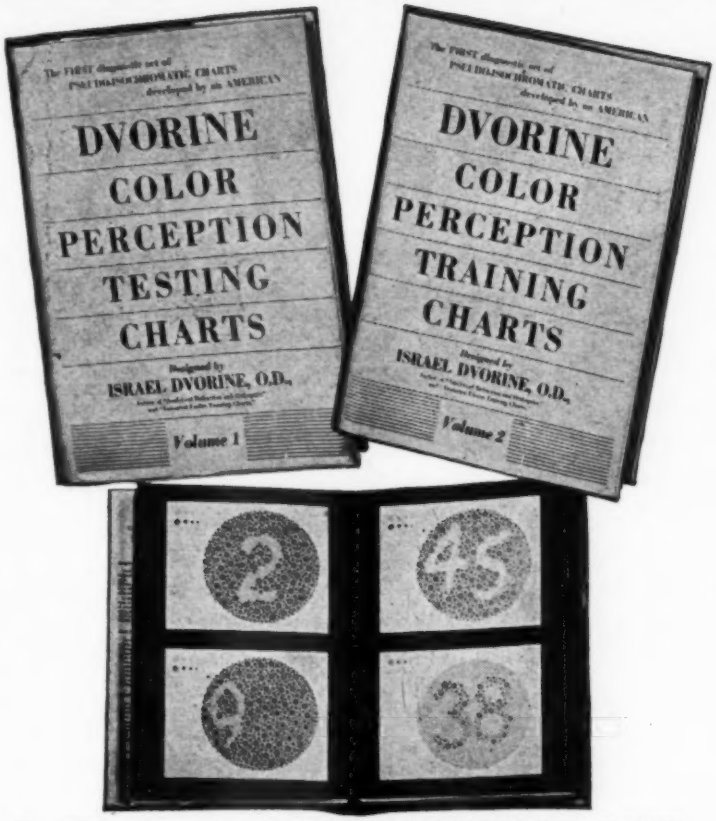

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